

WHAT IS CLAIMED IS:

1 1. A method for forming a trench having rounded corners in a
2 semiconductor device, the method comprising:
3 providing a semiconductor substrate;
4 forming a first pad oxide layer, a first silicon nitride layer, and a first oxide
5 layer on the semiconductor substrate sequentially;
6 removing portions of the first oxide layer, the first silicon nitride layer, the
7 first pad oxide layer, and the semiconductor substrate to form at least one trench;
8 removing portions of the first oxide layer, the first silicon nitride layer, and
9 the first pad oxide layer in the trench above an upper corner of the semiconductor substrate
10 in the trench, the semiconductor substrate including a lower corner at a bottom of the
11 trench;
12 forming a second pad oxide layer in the trench;
13 forming a second silicon nitride layer on the second pad oxide layer and the
14 first oxide layer;
15 removing portions of the second silicon nitride layer to expose the second
16 pad oxide layer on the corners and the bottom of the trench;
17 forming a thermal oxide layer on the second pad oxide layer exposed by
18 removing the portions of the second nitride layer; and
19 removing the second silicon nitride layer, the thermal oxide layer, and the
20 second pad oxide layer.

1 2. The method of claim 1 wherein removing portions of the first oxide
2 layer, the first silicon nitride layer, the first oxide layer, and the semiconductor substrate is
3 performed by a photolithography process or an etching process.

1 3. The method of claim 1 wherein the at least one trench has a depth of
2 between about 1 μ m and about 3 μ m and a width of about 0.2 μ m and about 1 μ m.

1 4. The method of claim 1 wherein removing portions of the first oxide
2 layer, the first silicon nitride layer, and the first pad oxide layer in the trench is performed
3 using HF.

1 5. The method of claim 1 wherein the second silicon nitride layer is
2 formed by deposition.

1 6. The method of claim 1 wherein removing portions of the second
2 silicon nitride layer to expose the second pad oxide layer is performed by dry etching.

1 7. The method of claim 1 wherein the thermal oxide layer is formed by
2 thermal oxidation.

1 8. The method of claim 1 wherein removing the second nitride layer,
2 the thermal oxide layer, and the second pad oxide layer is performed with phosphoric acid.

1 9. The method of claim 1 further comprising forming a second oxide
2 layer in the trench and on the first oxide layer after removing the second silicon nitride
3 layer, the thermal oxide layer, and the second pad oxide layer.

1 10. The method of claim 1 wherein the second pad oxide layer is
2 formed over surfaces of the semiconductor substrate in the trench.

1 11. The method of claim 1 wherein removing portions of the first oxide
2 layer, the first silicon nitride layer, and the first pad oxide layer in the trench exposes the
3 upper corner of the semiconductor substrate in the trench.

1 12. The method of claim 1 wherein removing the second silicon nitride
2 layer, the thermal oxide layer, and the second pad oxide layer forms a rounded upper
3 corner and a rounded lower corner of the semiconductor substrate in the trench for a
4 trench-type metal oxide semiconductor device.

1 13. A method for forming a trench having rounded corners in a
2 semiconductor device, the method comprising:
3 providing a semiconductor substrate having thereon a first pad oxide layer,
4 a first silicon nitride layer on the first pad oxide layer, and a first oxide layer on the first
5 silicon nitride layer, and at least one trench extending through the first oxide layer, the first
6 silicon nitride layer, and the first pad oxide layer, and partially through the semiconductor
7 substrate; wherein the trench is enlarged above the semiconductor substrate along
8 sidewalls of the first oxide layer, the first silicon nitride layer, and the first pad oxide
9 layer; wherein the semiconductor substrate includes a lower corner at a bottom of the
10 trench and an upper corner below the sidewalls of the first oxide layer, the first silicon
11 nitride layer, and the first pad oxide layer;

12 forming a second pad oxide layer in the trench;
13 forming a second silicon nitride layer on the second pad oxide layer and the
14 first oxide layer;
15 removing portions of the second silicon nitride layer to expose the second
16 pad oxide layer on the corners and the bottom of the trench;
17 forming a thermal oxide layer on the second pad oxide layer exposed by
18 removing the portions of the second nitride layer; and
19 removing the second silicon nitride layer, the thermal oxide layer and the
20 second pad oxide layer.

1 14. The method of claim 13 further comprising forming a second oxide
2 layer in the trench and on the first oxide layer after removing the second silicon nitride
3 layer, the thermal oxide layer, and the second pad oxide layer.

1 15. The method of claim 13 wherein the second pad oxide layer is
2 formed over surfaces of the semiconductor substrate in the trench.

1 16. The method of claim 13 wherein removing portions of the first
2 oxide layer, the first silicon nitride layer, and the first pad oxide layer in the trench
3 exposes the upper corner of the semiconductor substrate in the trench.

1 17. The method of claim 13 wherein removing the second silicon
2 nitride layer, the thermal oxide layer, and the second pad oxide layer forms a rounded
3 upper corner and a rounded lower corner of the semiconductor substrate in the trench.

1 18. A method for forming a trench having rounded corners in a
2 semiconductor device, the method comprising:
3 providing a semiconductor substrate having thereon a first pad oxide layer,
4 a first silicon nitride layer on the first pad oxide layer, and a first oxide layer on the first
5 silicon nitride layer, and at least one trench extending through the first oxide layer, the first
6 silicon nitride layer, and the first pad oxide layer, and partially through the semiconductor
7 substrate; wherein the trench is enlarged above the semiconductor substrate along
8 sidewalls of the first oxide layer, the first silicon nitride layer, and the first pad oxide
9 layer; wherein the semiconductor substrate includes a lower corner at a bottom of the
10 trench and an upper corner below the sidewalls of the first oxide layer, the first silicon
11 nitride layer, and the first pad oxide layer; wherein a second pad oxide layer is formed in

12 the trench and a second silicon nitride layer is formed on the second pad oxide layer and
13 the first oxide layer;
14 removing portions of the second silicon nitride layer to expose the second
15 pad oxide layer on the corners and the bottom of the trench;
16 forming a thermal oxide layer on the second pad oxide layer exposed by
17 removing the portions of the second nitride layer; and
18 removing the second silicon nitride layer, the thermal oxide layer and the
19 second pad oxide layer.

1 19. The method of claim 18 wherein removing portions of the first
2 oxide layer, the first silicon nitride layer, and the first pad oxide layer in the trench
3 exposes the upper corner of the semiconductor substrate in the trench; and wherein the
4 second pad oxide layer is formed over surfaces of the semiconductor substrate in the
5 trench.

1 20. The method of claim 18 wherein removing the second silicon
2 nitride layer, the thermal oxide layer, and the second pad oxide layer forms a rounded
3 upper corner and a rounded lower corner of the semiconductor substrate in the trench for a
4 trench-type metal oxide semiconductor device.